

Design, Deployment and Evaluation of an Internet-based Clinical Data Delivery Solution

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Developing and deploying informatics solutions which are useful and acceptable to busy physicians is a challenging task. It is insufficient to design and implement systems merely because it is now possible to do so. There must be a reasonable expectation that measurable benefits will result from such systems, and that the systems will be adopted by the intended users. Computer-based solutions, if improperly conceptualized and implemented, may at best simply convert ineffective paper-based systems into equally ineffective electronic systems, which are potentially much costlier. In practice, the complexities of existing and substantially functional paper-based systems are commonly underestimated. The result is that hasty electronic solutions are devised which completely overlook—and therefore do not duplicate—critical functional components of the systems they are intended to replace. The effect of such an ill-planned approach is not merely the lack of measurable benefit, but a measurable loss of functionality. Established clinical workflow patterns can be disrupted, and if the paper-based system is rendered non-operational by the electronic system, violating the injunction *primum non nocere* becomes more than theoretical. Yet, overly-ambitious solutions may be so comprehensive as to never reach production.

We assessed the possibility that an electronic data delivery system might address known deficiencies in an existing paper-based system for delivery of clinical laboratory reports at Duke Family Medicine Center (DFMC). Although the problems inherent in this system seemed obvious, the design and deployment of an adequate replacement proved to be a non-trivial task.

We first began with problem definition, and determined that in addition to known problems, other related inadequacies were intrinsic to the paper-based system. These problems did not always reflect the fact that this system relied on paper, but were instead fundamental design flaws of the existing system. We discovered that delivery problems were compounded by the participation of multiple individuals in the delivery process, and by the absence of an audit trail by which the process of information flow could be tracked. This made more understandable the limitations of the current system.

Analysis of the current system revealed a remarkable degree of functionality. Printed lab reports provided several concrete benefits: 1) data were available at a on a generally reliable basis, 2) data were legible, 3) data were presented in context, 4) data were properly filtered to remove extraneous data, 5) a primitive but effective mechanism of forwarding data in a provider's absence had emerged, and 6) the printed medium pro-

vided a crude form of (nonelectronic) data exchange between clinicians. The above functionality allowed us to both understand the deficiencies of the paper-based system, and to separate those which were due to the data delivery medium itself from those which were more fundamental in nature. We learned that 1) availability of reports at a single location often prevented a timely retrieval of those data by clinicians; this was taken to be a limitation of the actual delivery medium. In addition, 2) the time between electronic availability of summary data within the CPR to their first physical availability was often unacceptably protracted. Next, 3) while a paper "forward-to" notice placed on a provider's physical mailbox would ensure that lab reports were diverted to another provider's box, delivery and receipt of lab reports was undocumented. Though paper reports could be conveniently annotated by clinicians, and handed to other providers, 4) exchanges of information between providers was also dependent upon geographical proximity. Finally, we found that although the lab data originated from DFMC's computer-based patient record, TMR, 5) provider responses to these lab data reports could not be transmitted directly back to TMR.

Based upon our findings, an e-mail lab report delivery solution was designed and implemented at DFMC, using a randomized, controlled trial. This study assessed specific system performance measurements, including timeliness of delivery and receipt, and the impact upon the quality and patterns of physician-generated medical documentation. The design, deployment, and evaluation of the system utilized an active Internet connection, and provided controlled access to reports via the Internet, as well as local access. We maintained all of the functionality of the paper-based delivery system; its deficiencies were eliminated. We were implemented this solution with minimal changes in the data format to which providers had become accustomed. Furthermore, since the clinicians were already using the e-mail system for other purposes, we incurred no significant costs, imposed no significant learning requirements on our clinicians, and thus were able to fit our solution into the existing workflow patterns of the physicians. The new system is approximately \$14,000 less expensive than the one it is replacing. The system automatically documents delivery and receipt of reports, and encourages electronic responses to reports for entry into the patient record. There is *passive documentation* by the system, and provider-driven *active documentation* by return e-mail. An open, non-proprietary, design makes the solution readily generalizable to other systems, both existing and those under development. It also is extensible. User acceptance was high, based on direct feedback and results from a formal survey.